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ABSTRACT

Six conference panel discussions on uses of technology in education are presented. The first panel, "The Use of Hypermedia in the Teaching and Learning of Programming" (Tom Boyle, Chair, and others) discusses achievements in hypermedia-based instruction, design needs, and experiences. The second panel, "Virtual Clayoquot Video Database: The Bayside Middle School Implements a Networked Multimedia Socio-Scientific Study about a British Columbia Rainforest" (Ricki Goldman-Segall, Chair) describes the implementation of a science and social studies computer-based learning environment at a Vancouver Island (Canada) junior high school. The purpose of the "Virtual Clayoquot" project is to enable students to conduct their own research in order to become informed decision makers about socially important scientific issues. The third panel, "Internetworking for K-12 Education" (Vicki Hanson, Chair, and Nancy Butler Songer) discusses the use of innovative learning models and telecommunications technologies to bring the experience of "real" scientific investigations. The fourth panel, "Can Electronic Games Make a Positive Contribution to the Learning of Mathematics and Science in Intermediate Classrooms?" (M. M. Klawe, Chair, and others) discusses the potential of electronic games for learning mathematics and science in the middle grades. It closes with an exploration of both favorable and critical beliefs held by teachers and parents. The fifth panel, "Multimedia Publishing in Education: New Platforms, Products, and Markets" (Karen B. Levitan, Chair) discusses the changes in multimedia publishing for education from the point of view of both traditional textbook publishers and nontraditional organizations entering the publishing arena. The sixth panel, "Distance Learning" (Robert J. Seidel, Chair, and others) discusses the effectiveness and costs of distance education and its uses in military training. (AEF)

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PANEL DISCUSSIONS

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PANEL

The use of hypermedia in the teaching
and learning of programming

The Use of Hypermedia in the Teaching and Learning of Programming

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Learning to program involves a complex range of abilities in the design, coding, and testing of software. Students have to acquire skills in expressing solutions in a programming language, visualising the run time behaviour of their programs, and constructing tests of correctness. Increasingly, for many institutions, these skills have to be taught to large numbers of students from a wide diversity of backgrounds. A number of sophisticated learning environments have been developed to meet this teaching and learning challenge. These approaches differ in their emphasis on pedagogical approach and the areas of programming skill covered. Some of the systems are in mainstream use by thousands of students. Others represent advanced hypermedia prototypes. In this panel we will review what has been achieved in the use of hypermedia for the teaching and learning of programming and consider the design features of the next generation of hypermedia-based systems for programming education.

The panel members will describe their experience in designing a variety of hypermedia or hypermodal learning environments for programming. The DESIGN TOOL (University of Texas) and the CLEM and Braque systems (Manchester Metropolitan University) provide advanced interactive environments for learning design and implementation skills. The Genie systems (Carnegie Mellon University) provide sophisticated support for multiple program views and an integrated visual debugger to support hypermedia literate programming. The ISIS-Tutor (ICSTI Moscow) aims to link ITS and hypermedia components to provide adaptive guidance for the learner. The problems of developing hypermedia learning environments for large distance learning communities are being tackled at the Open University in England.

Based on their extensive experience the panel members will discuss the use of hypermedia features to support various aspects of the programming process. These include:

- the learning of abstract design skills
- learning language syntax and semantics
- support for program comprehension, visualisation and testing

I will raise a number of points based on experience with the CLEM and Braque systems. The main issues are:

1. the need for a coherent base in the psychology of learning and problem solving for the design principles which guide the construction of such systems. The psychology of natural language development has proved to be a particular rich source of insights;

2. how to maintain coherence in very large learning environments used by a wide variety of learners;

3. the role of empirical feedback on systems, based on use in real learning contexts, for both formative and summative evaluation;

4. the potential for the integration of design ideas and tools developed at different international centres.

The problems and proposed solutions discussed by the panel should be of interest to those involved in using hypermedia to support the learning of complex, structured skills.

Integrating Intelligence and Hypermedia in the Teaching and Learning of Programming

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I will discuss our experience of designing a hypermedia component in an intelligent learning environment (ILE) for programming. An important feature of any ILE is the use of knowledge about the domain and the student. In our ITEM/IP and ISIS-Tutor environments we represent the domain knowledge in the form of a network of programming concepts and constructs. This network reflects the structure of the domain and is used as the basis for both the overlay student model and the hypermedia network, which represents all teaching material: explanations, examples, tests and problems.

One of the main goals of our ITEM/IP and ISIS-Tutor projects was to investigate the ways in which hypermedia components can be integrated with an educational programming environment and an intelligent tutoring system for programming. I will discuss the following three aspects of our approach:

1. Support of multiple navigation paths between hypernodes of different kind.

Each of programming concepts or constructs has a hypernode as external representation. Each teaching operation of any kind (examples, problems, etc.) is also represented as a hypernode. Each relationship between concepts is represented as a bi-directional pathway. Moreover, each teaching operation has bi-directional hyperlinks to all concepts and constructs related with this operation. At any concept hypernode the student can get lists of related concepts separately for each kind of relationship, lists of all related teaching operations separately for each kind of operation and navigate to any listed hypernode. At any teaching operation hypernode the student can get the list of all related concepts and constructs and navigate to it.

2. Integration of exploratory environment and hypermedia

Each teaching operation which deals with programs or programming constructs (examples, tests, problems) is a door to the programming laboratory. The laboratory is equipped with visual interpreter and structure editor and used to play with examples, to answer tests, or to solve problems. The student can also work with the laboratory in the exploratory mode.

3. Integration of guided tutoring and student-driven learning

The tutoring component and the hypermedia component of ILE use the same student model to represent the results of student learning. Using this model the tutoring component can suggest at any moment of learning next "best" teaching operation, thus providing the required guidance. If the student is not satisfied with system choice, she can select next teaching operation herself with hypermedia links.

4. Adaptive hypermedia.

The hypermedia component uses the student model to adapt itself to the given student. First, the content of the hypermedia page is adapted to the student knowledge. Second all the lists of hyperlinks to related concepts and teaching operations are adaptive. Not ready to be learned concepts and operations are dimmed and others are marked in two or three colors according to the current state of student knowledge on it. Visual marks support student orientation and navigation in the hyperspace of teaching material reporting what is new, what have been learned, or what needs further work.

The Use of Hypermedia in the Teaching and Learning of Programming

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My remarks will be based on experiences gained in using the MacGnome Programming Environments. Included are the Karel Genie, the Pascal Genie, the Object Pascal Genie and the ACSE environment. These environments have been used in teaching programming and computational. We believe over 100,000 students have used one or more of these environments as a major programming environment in regular coursework. They have been used at a number of leading universities, colleges, and secondary institutions.

The Genies, as the MacGnome environments are collectively known, illustrate the power of multiple program views, complete incremental static semantics, a fully integrated visual debugger, a continual cycle of refinement based on user testing, and the full integration of hypermedia in support of hypermedia literate programming.

I will raise 5 issues:

1. What is the importance of the various system components? What can be eliminated from systems that actually do the job?

2. What is the impact of hypermedia as we have used it, on the learning process?

3. What role exists for hypermedia that we have not yet explored?

4. What does the distinction between teaching environment and professional environment imply?

5. What is our view of programming as an independent skill and how does that effect the tools we build and the way we teach?

An Environment Supporting Computer Science Education Integrating Hypertext, Program Design, and Language Facilities

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I will discuss our experience integrating a visually-based design and programming environment with a hypermedia presentation of course content. The environment provides students with a suite of pedagogically oriented programs. The programs and interrelationships among programs are designed to support independent development of each of the skills necessary for programming, while keeping the integration of the skills and the more abstract concepts of computer science in sight.

A student oriented CASE tool supports a pedagogy which focuses on developing general problem solving skills as an integral part of programming. Design Tool uses a visually based system for problem decomposition, program design via structure charts, data flow checking, Pascal code generation, and report writing. Students' first experiences in the laboratory environment involve the completion of design exercises.

Design Tool provides general tree display facilities for module creation and deletion, module reordering and repositioning, and the collapsing and expanding of subtrees and module windows. An overview diagram provides an orienting view of the entire design and navigation facilities for moving around within the design. A student oriented pseudocode language, focusing on data flow and consistency, allows students to focus on algorithm development. Constraint checking eliminates errors in data flow prior to code generation and a move to the implementation facilities. Code generation facilities allow the student to design moderately complex problem solutions and remain focused on the problem solution and design, rather than on a particular language or programming environment.

A hypertext notebook serves to integrate concepts introduced in the classroom and text with details of design and implementation. The notebook contains the course lecture material, course syllabus, schedule, laboratory exercises, programming assignments, and a large set of designs and example programs. One feature of the hypertext, Quick Look screens, provide a brief explication of a concept. The screens provide a readily available and easy to use help facility for programming language semantics and data structure concepts analogous to the syntax help facilities in most programming environments. The hypertext is implemented in a system which allows direct transfer of information to both Design Tool and the programming environment, serving to physically and conceptually relate more abstract concepts to details of design and implementation.

We have used questionnaires to assess student response to the tools, and attitudes toward design and implementation concepts. Pre- and post-test exercises, and a standardized series of assignments and exams provide insights as to the effect of the tools on student understanding and skill development in problem solving, design, and implementation in a structured programming language.

The discussion will focus on 1) how to integrate the principles of program design with the practice of programming through a student-oriented CASE environment, 2) how to broaden the scope of learning during the programming process through an integrated hypermedia presentation of information, and 3) the effect on students of the approach we have taken.

The Use of Hypermedia in the Teaching and Learning of Programming (A Distance Education Perspective)

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Hypermedia technology is of significant potential benefit to students in the distance learning mode – isolated from their peers and tutors. However, there exist significant problems to do with the design and use of such hypermedia systems to support the teaching and learning of programming.

I will report on current developments in multi-media teaching of programming and software development at the Open University and discuss issues which are of strategic importance for both distance learning and for student-centered learning in the conventional sector. The Open University is the UK's distance learning university, offering an open-access modular degree programme which includes high-population courses in computing. The average age of student is 35. At present most students in the introductory course have previously studied a foundation course in mathematics or technology. Despite this fact we are observing a decrease in abstraction skills and a reduction in the ability to manipulate symbols. Over the past five years we have increased our number of students studying courses in software development to more than 6,500 per year. I will report on the use of hypermedia in a major project to replace our flagship introductory course at the beginning of 1997; the new course is planned to have in excess of 3,500 students per year.

A number of problems face the team developing the course and the solutions to these may lie in the use of advanced multi-media technologies. I will describe how these have been addressed in the functional specification and design of software for the new course. We are developing a hypermedia-based teaching environment to which our own and third-party software must interface.

In particular the following issues will be addressed:

1. Concepts of programming and software development are not being sufficiently deeply understood by students. To some extent we believe that current approaches to the teaching of programming do not develop abilities to reason about complex software and are developing tools to assist students in this respect. How can we use hypermedia to improve abstraction skills and deepen understanding of programming?

2. Increasingly students start software courses with little experience of manipulating symbols and many will have no experience of independent study. To what extent can a lack of mathematical, problem solving and notation manipulation skills be mitigated using hypermedia? In addition, how can the technology simultaneously cater for those who have few initial skills and those who are impatient to progress?

3. The cost of changing printed correspondence material and recording audio and visual material for broadcast is high. Do we need to organize our media differently if it is to be computer-based? Strategies for mixing computer-based teaching, printed material, and television and radio broadcasts will be described; in particular, paper-based hypertext that mimics computer-based systems will be discussed.

4. Software and hardware technology changes at a rate that is impossible to ignore and difficult and costly to track. Will the multi-media systems we develop really be amenable to change or will they become too tightly coupled to software development methods and programming language types?

PANEL

Virtual Clayoquot video database:
The Bayside Middle School implements a
networked multimedia socio-scientific study
about a British Columbia rainforest

VIRTUAL CLAYOQUOT VIDEO DATABASE: The Bayside Middle School Implements a Networked Multimedia Socio-Scientific Study about a British Columbia Rainforest

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Introduction

Virtual Clayoquot is the name given to a science and social studies computer-based learning environment for teenage girls and boys from the Bayside Middle School, a Vancouver Island junior high school, to explore the controversy over the future of a rain forest, on the west coast of Vancouver Island, called Clayoquot Sound (KLAK-WIT Sound). Over the coming years, we expect to (1) find out more about how these teenage girls and boys make sense of complex scientific issues – when the issues are significant to their daily lives and when they are studied across the curriculum, and 2) to find out how using networked multimedia applications will build a distributed community of inquiry. The collaborative team represented in this panel at EdMedia'94 consists of students, teachers, professors from two British Columbia universities, industrial liaison members, community-based science specialists and educators, and representatives from the Ministry of Education. Produced over the next few years will be the product, *The Virtual Clayoquot Magazine*, a series of CD-ROM disks. The purpose of the *Virtual Clayoquot* project is to enable young people to conduct their own research in order to become informed decision-makers about socially important scientific issues. Our plan is to have these young people electronically discussing their research with other children from rainforest and wetland regions, using a mail program called *CLIENT*, developed at the Educational Technology Center (ETC). From the moment the young people began their investigations, a team of faculty and graduate student researchers initiated an ethnographic research about the thinking styles used by these young people, paying particular attention to the different approaches used by teenage girls and boys. Thus, issues concerning gender and science (Linn & Hyde, 1989) play a significant role in both the content and style of the video and text data that is being collected and analyzed. A data analysis software application called *CONSTELLATIONS* (Goldman-Segall, 1994) is the tool being used for building theories about the children's thinking and will be used as the interface for accessing the *Virtual Clayoquot* data on the CD-ROMs.

Theoretical Premises

Our research is based on three premises. The first premise is that a relevant subject matter as controversial as the forest dispute at Clayoquot Sound will provide powerful content across the curriculum area for this group of young people to construct their own transformative theories. Another underlying premise is that learning occurs best when people study in a manner that is complementary to their own preferred way of thinking (Goldman-Segall, 1991). (This does not imply that learning does not occur when the subject matter is not relevant or requires using a non-preferred style of thinking.) The third premise is that emerging electronic media can support human inquiry by providing ethnographic methods of evoking and provoking the learning process. In fact, multimedia learning, in this environment, becomes a post-modern ethnographic encounter wherein the researcher, the researched (the content), and the reader of the research negotiate meaning. As Tyler points out:

> A post-modern ethnography is a cooperatively evolved text consisting of fragments of discourse intended to evoke in the minds of both reader and writer an emergent fantasy of a possible world of commonsense reality, and thus to provoke an aesthetic integration that will have a therapeutic effect. (Tyler, 1986, p. 125)

Learning in a constructionist multimedia environment is also an aesthetic integration that blends the learner, the various media (including the teacher), and the message (or content) into one contiguous web.

The second premise requires explanation as it deals with how we know what we know about the world around us, our epistemological point of view. Traditionally, epistemological theories support the existence of levels or stages of knowledge – Piaget's stages of intellectual development being a good example. Carol Gilligan (1982) suggests that there is a "different voice" or model to the hierarchical one. Turkle and Papert (1991) call for an epistemological pluralism, where both "hard thinking" and "soft thinking" are equally significant styles of thinking. Papert's learning theory recognizes all learners as constructionists moving from novice to expert in accordance with their style of thinking. Papert and Turkle's theory is that, traditionally, hard thinking in science has been the basis of defining logical thinking. "And logical thinking has been given a privileged status which can be challenged only by developing a respectful understanding of other styles..." (1991). According to Papert & Turkle (1991), soft thinking is more negotiational and contextual, or what Lévi–Strauss terms, *bricolage*. In other words, science is not the pure, "objectively" neutral endeavor that traditional theorists once claimed it was. More and more, we are coming to agree that science is a culturally shaped construct by those who engage in its activities (Solomon, 1987). As the people who do science change, the paradigms change (Kuhn, 1970). A relational approach to conducting scientific explorations offers a wider range of ways to doing science. Fox Keller calls science a "deeply personal as well as a social activity" (1985, p.7). In the *Virtual Clayoquot* study, the relational and personal approach to doing science is expanded upon in order to closely examine epistemological pluralism. We might hypothesize that scientific knowledge is also a tool for relationships with the world in which we live, and not only an area of inquiry in and of itself. Thus, studying the Clayoquot provides an opportunity for students to use their relational, narrative, or empirical styles of thinking to build theories about a complex subject.

Method of Conducting *Virtual Clayoquot* Study

Young people are partaking in three diverse roles in this project: they are researchers, designers, and distance educators.

Young People as Researchers: Several teams of young people and their teachers are investigating the issues surrounding the dispute primarily concerning the future of old growth forests and the economic well-being of local communities. Teenage girls and boys have opportunities: to visit the site; videotape their impressions of the forests; interview loggers, protesters, community members, and government officials; and collect relevant articles from newspapers, magazines, and scientific journals. Along with adult expert resource persons, they interpret the video and text data from a variety of perspectives: forest and wildlife issues; employment needs; First Nations peoples' claims; municipal and provincial priorities; trade agreements; and, global concerns', to name a few.

Young People as Science Curriculum Designers: Girls and boys of the Bayside Middle School will use *CONSTELLATIONS* to classify, categorize, link, and analyze the data. Students will search through large databases, build "constellations" or groups of data, and construct interpretations based on their own findings. They will selecting the most relevant data as the basis for a learning module to be made available on CD-ROM.

Young People as Distance Educators: We expect that this multimedia module on Clayoquot Sound will be composed so that other young people will be encouraged to make informed decisions about this controversial social, cultural, and scientific issue. Our long-term vision is to take advantage of emerging technologies such as large networks that can encode and decode multimedia information. This will enable young persons from the

Bayside to have real-time video-based discussions with children in other schools. Currently, these young people are in electronically linked to the World Wide Network using *CLIENT*.

The following is a list of the activities that the young people are either engaged in currently, or will be engaged in within the following years of the project:

- investigating the issues surrounding the Clayoquot Sound dispute from as many perspectives as possible and through as many recorded media as available.
- debating the issues in class on a semi-regular basis and have this be part of the database.
- visiting the site and conduct a series of interviews using video, tape, pen and paper, and portable computer.
- assembling the text, sound and video data to analyze using *CONSTELLATIONS*.
- designing the overall CD-ROM architecture for other young people.
- conducting school surveys about attitudes and ideas for change.
- using human expert resources at various locations in British Columbia and elsewhere.
- becoming resource persons for others interested in the rain forest issue in BC.

The following is a list of the activities that the faculty and graduate student researchers are either engages in currently, or will be engaged in within the following years of the project:

- involving young people in our research about them and let them study us, if they choose.
- co-ordinating the methodological approach for analyzing the data about the process.
- conducting interviews and observations of events that demonstrate the specific ways in which gender differences can enrich the scientific process.
- developing a more relational approach to reporting our findings.
- becoming part of the student research team so that we are all making contributions that bring out our best.
- studying and share what we know and what we don't know with our peers and our community.

Multimedia Tool, *CONSTELLATIONS*, for Analyzing Data

Over the past eight years, I have been working closely with colleagues from the MIT Media Lab and with computer scientists at UBC. During this time, I have been developing a theory of how to layer data so that the meaning of the a recorded event could be easily communicated and understood in a multimedia documentation (Goldman-Segall, 1993). I also designed with two separate research teams different versions of *CONSTELLATIONS*, which are software applications for annotating, linking, and juxtaposing media forms into multimedia documents. In both systems, the researcher can build layered descriptions upon which she and others can e-VALUE-ate the validity of her conclusions in the following ways:

- Building groupings that are similar (clustering, stacking)
- Thickening the description with annotations
- Linking across attributes: slicing through the layers
- Signifying the meaning by add "weight" to the attributes
- Adding perspectives and "points of viewing;" triangulation
- Juxtaposing video/text/sound in diverse configurations
- Making fine-grained selections
- Fine tuning, trimming, narrowing focus, reaching core concepts

Let me expand upon a few of these ways of layering and explain how students and researchers could use this method for their investigations. One way of layering our understanding occurs during the process of interpretation when multiple users comment upon, or annotate, the same video stream. As they annotate, they thicken (Geertz, 1973) the data because each user interprets the same event quite differently. Multimedia designers are now beginning to realize that diverse users manipulate video data differently. The likelihood of conclusions being the same is minuscule. The possibility of them falling into the same range (Geertz, 1973) is likely.

Having access to multiple forms of representations of research data – video, text, sound – also adds to the building of layers. The days where text was the only legitimate form of data are over. The use of sound, photographs, video or film, or drawings and sketches have become commonplace. However, most computer applications treat researchers as being married to one form — usually to text. It is possible to add a digitized image or a QuickTime movie to a text document, but if the researcher wants to codify this data with the other data, she must resort to using either a text-based, video-based, or sound-based application. In *CONSTELLATIONS* all data forms can be codified and linked as equal but different forms.

However, the kind of layering that is more crucial is a result of what happens when data are shared. How can members of a research team explore the various significant ratings of colleagues? In other words, can

layering enable the researcher to get a sense of seeing the data from other perspectives in order to triangulate interpretations? These and other questions will be addressed in this panel discussion and demonstation of the tools we are using.

Panel Topics

Instead of concluding with the findings we have made to date, I would like to take this opportunity to highlight a few of the central topics that the team of panelists will be presenting as the first phase of the project. draws to a close Jordan Tinney, a teacher at the Bayside, will describe the process of enabling his students to study the various points of view surrounding the dispute. Tinney's students (grades 6 and 8) studied the Clayoquot Sound dispute for over two months in his social studies classes. He will describe the projects students assembled and the kind of thinking they had about the issues before and after the immersion. Lauri Roche is the teacher of a special needs class. Three of her students participated in Jordan's class throughout this first stage. Roche will describe the creative approaches used by her students to offer solutions for how to resolve some of the issues. Kathryn Godfrey has been active in global education for several years. Her class has taken a broad view of how to understand ecological issues. She will describe several activities that her students have done to help them reflect upon these issues. Keven Elder, the vice-principal of the school. will provide the overall school commitment to exploring multiple points of view and will explain the philosophy of the school culure in light of new technologies, as it approaches the year 2000. Ted Riecken, a faculty researcher from the University of Victoria, will discuss the overall research agenda at Bayside and how this project fits into a pattern of research that he and his colleagues initiated three years ago when the Bayside teachers were still at the old school site. Rieken will also describe his methodological approach in building narrative ethnographic accounts. Leslee Francis Pelton, Riecken's colleague at UVic, will describe how an issue such as Clayoquot can be studied across the curriculum.. She will bring her mathematical perspective to the project showing how issues such as Clayoquot Sound help children to understand the interaction of Science/Math, Technology and Society. Michael Hoebel from the Educational Technology Center (ETC) will discuss network issues with other schools and the BC commitment to learning technologies. In fact, Hoebel and his team at ETC, have been the technology pioneers in British Columbia. Hoebel will be able to describe, not only the current work he is involved in at the Bayside, i.e., *CLIENT*, but provide the historical perspective of how computers have entered into the lives of children and their teachers in BC schools. Goldman-Segall will show data that has been gathered in phase one, show excepts of the data, report findings to date, and describe the next phase of this action-oriented research project. We welcome you to join us to hear about the developments and contribute to its progress through your questions and quieries.

This research is supported by a Social Sciences and Humanities Research Council of Canada (SSHRC) grant called, Video and Validity: A Multimedia Collaborative Research Tool for Representing What We Record, Interpret, and Share with Others and by the Natural Science and Engineering Research Council (NSERC) of Canada Strategic Research Grant (#5-81457) called Logging, Annotation and Navigation for HyperMedia Video Analysis Tools.

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PANEL

Internetworking for K-12 education

Internetworking for K-12 Education

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The use of the Internet in K-12 education has the potential for radically changing the way students learn. This resource represents thousands of connected networks around the world that allow teachers and students to access and share resources beyond their school walls. It provides a unique ability to collaborate and communicate with other students and teachers world-wide. It also provides a timeliness for current events and data-gathering otherwise unavailable.

Simply giving access to this rich array of information, however, does not guarantee its effective use. If schools are to be more than passive receivers of this information, they will need to learn how to productively explore and use this resource. Spurred by interest and funding at the state and national levels, researchers have begun investigating issues related to training of teachers in the use of this technology and related to the exploration of new instructional techniques using collaborations of students from different parts of the globe.

Participants in this panel have all been involved in pioneering projects designed to make the Internet accessible for both students and their teachers. Panelists will discuss their large-scale state and national pilot projects on teacher training, classroom reform, and educational policy related to introduction of the Internet into K-12 education.

In Texas, for example, teachers and students use a state educational network to link to Internet resources. The number of teachers using this system has grown exponentially, indicating educators' interest in taking advantage of these resources. Their use of the Internet through this state system will be discussed.

The Kids as Global Scientists project deals with questions of classroom reform, centered around the use of the Internet. The results of this research suggest ways in which the type of knowledge students acquire through this collaborative learning experience differ from the type of knowledge they acquire through traditional instructional approaches.

The NSF-National School Network Testbed has been addressing technical and policy issues involved in scaling up the Internet to a point where it is universally accessible by all K-12 students, teachers, and administrators. In large part, this involves making available information, materials and services of sufficient value to generate investment by schools and government.

New Learning and New Learning Models with Kids as Global Scientists

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The Kids as Global Scientists (KGS) project focuses on the orchestration of classroom reform using innovative learning models and telecommunications technologies to bring the excitement of "real scientists'" investigations into middle school classrooms. In addition, we couple our design of reform classrooms with detailed investigations of student learning.

Students in our Internet Hub classrooms utilize a Hypercard front-end software tool called *InternetTrek* to regularly access real or near-time spectacular satellite images and weather maps which characterize the path of weather phenomena over the globe. Simultaneously, they correspond through electronic coordinated exchanges with middle school students and professionals world-wide. Most importantly, the coordinated activities and software support students' investigation into their own questions in Atmospheric Science. Our activities promote questioning, collaboration and the exchange of first-hand information from students who are experiencing the phenomena and who might be thousands of miles from their correspondents' classrooms. In addition, the anonymity of electronic correspondence has, in several instances, encouraged students to excel who are sometimes marginalized by face-to-face peer activities.

Preliminary results indicate that students using our Global Exchange learning model and telecommunications technologies for the gathering and exchange of information demonstrate distinct differences in the type and value of knowledge developed from what might be obtained in more traditional learning environments. We have found that learning about science as the science is occurring (which we call *today's knowledge*) and through dialogue and exchange with peers who share similar perspectives (which we call *interactive knowledge*) are powerful approaches to learning. We have begun to characterize these emerging learning differences, and their influence on student knowledge development and motivation to learn science. To illustrate one aspect of today's' knowledge, we share a quote from a student, "They [the students in the other locations] give you their point of view of the weather not what other books give you...every day is the same to books." We continue to investigate the nature of the knowledge developed, and the potential for our classroom reform to enhance understandings.

PANEL

Can electronic games make a positive contribution
to the learning of mathematics and science
in intermediate classrooms?

The Educational Potential of Electronic Games and the E-GEMS Project

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The panelists are members of the Electronic Games for Education in Math and Science (E-GEMS) research team. E-GEMS is a collaborative effort by educators, computer scientists, electronic game designers, scientists, curriculum designers, and mathematicians, to increase understanding of how math and science learning can be aided by the use of electronic games. E-GEMS is engaged in the study of existing electronic games and in the design of new games in an effort to encourage more children to explore issues in mathematics and science, combining learning through electronic games with school curricula, tools, materials, and practices.

Electronic games are an important part of the popular culture of many North American children. Video game arcades have been eclipsed by the home video game units found in countless living rooms -- *Nintendo* has become a household word. Even children who don't have a video game system at home are aware of this sweeping phenomenon: video games are popular and influential (Papert, 1993; Provenzo, 1991).

Few schools have incorporated video game technology into the curriculum. If electronic games are played in school settings, they are most often played on computers, and the games have ostensibly been designed for educational purposes. It is unlikely that the designers of commercial video games -- like *Street Fighter II* -- had explicit educational goals in mind. Nevertheless, the panelists hold the view that electronic games -- both computer and video -- have a place in the school curriculum, and moreover, that electronic games can be designed to enhance the teaching of mathematics and science in intermediate (Grades 4-8) classrooms.

I will open the panel by taking the position that electronic games can do more than entertain children. I believe there could be considerable curriculum content embedded in many electronic games, even in games that appear to be primarily designed for entertainment. The exploratory and interactive nature of electronic games is ideally suited to encouraging the exploration of mathematical and scientific concepts. Moreover, electronic environments facilitate visualizations and manipulations that are difficult to achieve with concrete materials. Existing games that could be used in Grade 4-8 classrooms as an effective aid to teaching math and science include *The Incredible Machine* for physics, *SimCity* for many mathematical concepts including percentages, rates, measurement, perimeter and dynamical systems, and *Lemmings* for logic, percentages, and programming. Many popular video games (e.g., *Super Mario World, Zelda, Secret of Mana*) contain excellent puzzles for motivating the study of patterns and structures. E-GEMS has developed *Monkey Math*, a collection of prototype games and activities for the exploration of negative numbers and fractions.

Future research includes the possibility of using the attractiveness of video and computer games to challenge children to take interest in math and science. I believe electronic games can enhance the interest and confidence of girls with respect to math and science, interest and confidence which often is lost in the intermediate grades (Linn & Hyde, 1989; Woods & Hammersley, 1993). Also, I am convinced that electronic games can be used to encourage boys who are likely to drop out of high school, by capitalizing on their interest in electronic games, and using those games to help them become interested in school curricula.

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Teacher Mediation in an Electronic Games Environment

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I will comment on the types of learning that can occur through the playing of electronic games. I take the position that learning is more likely to occur through effective mediation on the part of teachers and/or teacher-researchers.

Imagine a "school" in the future, where children clamber to learn about long division, fractions, percentages, negative numbers, spatial relations, and the laws of physics by playing exciting electronic games. Gone are the repetitious worksheets, the tedious blackboard explanations by the weary teacher, and the uninterested looks on the faces of the students. Sound unbelievable? I think so, too, at least in part.

Electronic games are attractive to children, and learning can occur through the playing of electronic games. However, learning by playing is more likely to occur if it is coupled with effective mediation on the part of teachers. That is, to increase the realism in the above scenario, add a knowledgeable teacher who is comfortable with electronic games as teaching tools. Add, too, some related activities where the children explore, abstract, generalize, and extend the concepts they first became interested in by playing the game. Try to leave out the worksheets and the lectures.

Most children learn better when the goal concepts are embedded in a known, likable context. Electronic games can provide rich, attractive environments for initiating interest in math and science concepts. Once the interest is present, exploration of the game can be made more conducive to learning if the player is guided by an insightful mediator. A teacher can help the student to identify concepts in the game environment, as well as to abstract and to generalize the concepts by applying them in novel situations.

In our studies, we have found that many children interacting with a computer animation learn more about spatial concepts when the use of the computer is mediated by a teacher-researcher, and when the teacher-researcher uses manipulative materials to demonstrate and clarify the concepts contained in computer animation (Upitis et al., 1994). In addition, when children work in pairs, along with a teacher-researcher, they find the learning more enjoyable, use the computer for longer periods, and perform better on an external measure of learning (Inkpen et al., 1994).

We have also found the need to supplement an electronic game environment while using a game to teach children about gears and pulleys. Teacher-researchers guided play of the game *The Incredible Machine* to emphasize target concepts, used physical models to clarify the graphical simulation, and offered explanations that corrected inaccurately simulated physical laws. Despite the need for teacher augmentation -- or perhaps because of it -- children still enjoyed learning about gears and pulleys by playing *The Incredible Machine*.

By understanding the role of mediation, we will be in a better position to develop games and supporting materials that facilitate meaningful intervention by the teacher. Understanding and promoting the relationship between the teacher and educational materials is an essential step in the design of appealing electronic games that can be sustained in a school environment.

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Gender Differences in an Electronic Games Environment

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Both boys and girls can learn about math and science through the playing of electronic games. However, I also recognize that there are gender differences in the ways that boys and girls approach electronic games environments.

Our studies indicate that girls enjoy playing electronic games, particularly computer games (Inkpen et al., 1993). Further, girls often prefer to play with a friend, and will play longer if a friend or teacher is taking an active interest in the game. When asked to design their own video games, girls tend to concern themselves with the personalities of the characters in the video games and on a story line. They seem less concerned with tools and logistics of game design. We need to keep these trends in mind if we are to capture the interest of girls through the electronic game medium.

Many boys are sophisticated game players, although this sophistication need not be at the expense of losing interest in other activities or in school. Boys are often attracted to the video game subculture -- they trade games and magazines, attend game-playing parties, and have many conversations about video games. They also appear to be attracted to the fast action and violence of video games, although our studies indicate that most boys will play cooperatively, or will develop sophisticated turn-taking systems to ensure that everyone gets a chance to play (Lawry et al., 1994). We do not endorse the violence in video games, nor the subservient role that female figures often play. But will we lose the interest of boys if we incorporate elements of cooperation and collaboration into electronic games, or create games that don't pitch good against evil? Are there ways to design games that attract both boys and girls, and contain substantive math and science content? I believe there are.

Gender differences are also apparent in the cooperative play of children in an electronic games environment. In a study using *The Incredible Machine*, children were observed playing the computer game in various cooperative settings (Inkpen et al., 1994). Girls appeared to perform better when a pair of children played together on one computer. Boys in the study were most successful when two boys played together, each using their own computer. Sharing of the mouse during cooperative play also yielded interesting results. Girls showed a higher proportion of non-contact requests and few requests involving physical touching of the mouse or their partner. In addition boys exhibited a larger number of refusals to pass over control of the mouse than girls. With the current emphasis on cooperative work in the schools, as well as the focus on cooperative work in the business world, it is important to recognize and understand the behaviours exhibited by both genders in cooperative environments. With that understanding, game producers can generate appropriate games and interfaces, which, when used with supporting curriculum materials, can increase the impact of electronic games in home and school environments.

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Playing Styles for Computer and Video Games

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One of the potential contributions of electronic games is that they can simulate a variety of different contexts since the adaptable nature of the technology allows children to explore phenomena that would be difficult to simulate with other media. Another attractive feature of the electronic medium is that many different styles of play can be accommodated. These include having children play alone or cooperatively, or contributing without actually playing games (e.g., standing aside and watching and/or making recommendations). Children playing games can use a variety of strategies to solve problems, including trial-and-error or logical-sequential strategies. I have observed many strategies and styles used in the playing of computer and video games.

I also hold the view that children's playing strategies and styles can closely reflect their learning and thinking styles. Research shows that people have a diverse set of learning preferences and styles (Keefe, 1987; Lall & Lall, 1983; Schmeck, 1988). Keefe (1987) states that learning styles are hypothetical constructs that reflect the underlying causes of learning behaviour. He proposes a learning style model that has three dimensions: cognitive, affective, and physiological. All these dimensions determine people's preferred modes of learning. Torrance and Rockenstein (1988) provide an overview of a number of these learning preferences and styles: some learners are more inclined towards a logical-sequential structure in which thinking and problem solving are performed in a step-by-step and data-driven fashion, some prefer to learn through discovery, and some learn things in an intuitive way and make accurate generalizations. In practice, however, people seem to mix and match a number of these styles, adapting their choice to the particular problem they are trying to solve or to the creation they are trying to construct. Others, however, cultivate only a narrow band of styles, and by doing so, may fail to realize the potential of alternate approaches.

I believe that electronic games can be used to augment and broaden the skills, strategies, and styles in a child's repertoire. For instance, a slow-paced puzzle-solving game may promote a logical-sequential style. An adventure game, where the player has an array of tools from which to choose in order to overcome obstacles, may help develop discovery-based learning in children. In addition, there is research indicating that fast action games may contribute to spatial visualization (Lowery & Knirk, 1982). Traditionally, schools have promoted and rewarded a limited set of learning styles (e.g., logical-sequential approaches to mathematics). Even teachers who successfully accommodate a divergent set of styles can benefit from having electronic games that appeal to children with differing learning and playing styles. For these reasons, I am especially interested in hybrid learning environments -- where a single electronic game provides the player with multiple learning-style possibilities; where children learn through social interaction with their peers, parents, and teacher(s); and where the school setting provides many learning activities such as games, manipulatives, instruction, and so on, to support the playing of games in school and home environments.

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Parent and Teacher Attitudes towards Video and Computer Games

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The panel will close with an exploration of both favorable and critical beliefs held by teachers and parents about the playing of electronic games. While some parents and educators hold the view that electronic games can be valuable learning tools, many others believe that electronic games, especially video games, are at the very least vacuous and a waste of time, and at worst, lead to violent and aggressive behaviour. It would appear that at least some research substantiates the latter view (Graybill, 1985; Silvern & Williamson, 1987).

Although I enthusiastically share the goals of my colleagues on the E-GEMS research team, I myself fall into the class of adults who find video games unattractive. I have grave concerns about the violence embedded in many of the games, and about the ways that female figures are often depicted -- as passive creatures to be saved or prizes to be kissed (Provenzo, 1991). I also worry about children spending time playing video games when they could be doing other things -- playing outdoors or reading a book. These types of concerns are expressed by those parents and teachers who limit the amount of time the children in their care are permitted to play video and computer games, or ban games completely from the home and/or school (Lawry et al., 1994).

Nevertheless, I recognize the enormous potential of electronic games, and I realize that many children balance video game play with other activities and appear not to be adversely affected by the violent aspects of some of the games (Dominick, 1984; Lawry et al., 1994). The potential of video and computer games is also recognized by parents and teachers who claim that children develop problem solving strategies, learn to recognize complex patterns, and use decision-making criteria in playing games -- reason enough to pay attention to the electronic game phenomenon. But perhaps the most important reason of all to pay attention to electronic games is that it is indisputable that many children find the game culture compelling. Leggo (in press) makes a convincing case for the need to be responsive to the popular culture within the school environment, arguing that teachers can help children make responsible choices as they interact and respond to various popular forms of media.

It is because of the seemingly magical appeal of electronic games, and video games in particular, that I am interested in understanding their allure and capitalizing on their appeal in order to help children learn about math and science. We need to explore the attitudes of parents, teachers, children, and society members in general to see whether both positive and negative beliefs are well-founded, and act in accordance as we take on the enterprise of developing new games. I am convinced there are ways to design electronic games that appeal to children without involving violence, or portraying females in subservient roles. By ignoring the popular culture of video games instead of meeting it head on, we would not only blind ourselves to a strong cultural influence, but lose an opportunity that could have a strong positive impact on math and science education.

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PANEL

Multimedia publishing in education:
New platforms, products, and markets

MULTIMEDIA PUBLISHING IN EDUCATION: NEW PLATFORMS, PRODUCTS, AND MARKETS

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PANEL DESCRIPTION: With the continued improvements in multimedia hardware and software tools, and the integration of technologies for voice, data, full motion video and graphics, the publishing arena for educational products has been split open and new forces are shaping the marketplace. In addition to traditional textbook publishers, multimedia and the converging computer/communications technologies have brought hardware and software companies, telephone and cable companies, movie studios, and others into the traditional marketplace of textbook publishers. What do these changes mean for education? What will new products look like - for the hand, desk top, client-server network, distance education? How will these new media products be delivered? What kinds of relationships will publishers/disseminators have with educational institutions and their faculty/teachers? How will the purchasing process change? What impact will this have on teaching and learning? Educators need to know the answers to these questions.

This panel brings together a diverse group to explore the changes in multimedia publishing for education from points of view of both traditional textbook publishers and nontraditional organizations entering the publishing arena. Representatives from major publishing and software companies to address the above questions from their own marketing and product development perspectives.

PANELISTS AND PRESENTATIONS:

Scott C. Hardy, Director Media and Multimedia Development, *Harcourt Brace College Publishing, 3700 Commerce St, Suite 3700, Ft. Worth, TX 76102.* **Old Line Publishers in a New World Order: The Role of Traditional Textbook Publishers in Multimedia Instruction**

Felicia M. Woytak, President, *Beyond Books, 5337 College Ave., Suite 453, Oakland, CA 94618*
New Media Brings New Ways of Teaching, Selling and Training

Fred Benz, Manager of Product Marketing, *Kaleida Labs, Inc., 1945 Charleston Rd, Mountain View, CA 94043*
ScriptX: A Cross-Platform Language for Developing and Publishing in Education

Amy Satran, Multimedia Product Development Manager, *Wadsworth Publishing Company, Ten Davis Drive, Belmont, CA 94002.* **New Media and New Business Models in Higher Education**

PANEL

Distance Learning

Learning Without Boundaries
An International Overview of Distance/Distributed Learning

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The re-structuring of the U.S. military forces in size and composition, along with decreased funds for real exercises and equipment, has focused attention on how to maintain a well-trained and flexible force. These changes are affecting NATO as well. While NATO for years has been more interested in hardware and weapons technology, recent changes in economics, force structure, and the European infrastructure have stimulated a strong interest in education and training technologies. The Research Study Group on Advanced Technologies Applied to Training Design (RSG-16) was established by Panel 8 of the NATO Defense Research Group, in order to provide an active exchange of data, methods, models, and media throughout the NATO alliance.

While Distance Learning has been developed and used by the open university system for some time, the application to training in the vocational and school-to-work areas have had only a recent focus by Europe. The RSG has been focused on advanced technologies for team, multi-national, multi-service training. Such a focus allows the forging of conceptual links between the traditional approaches of Distance Learning (one-way knowledge dissemination from instructor to learner) and the requirements for distributed training (multi-way dissemination among teams, crews, etc). An RSG-16, NATO workshop was held in Munich, on September 29 through October 1, 1993 and dealt with these and the following topics.

1) Distance Learning/Distributed Training lessons learned - commercial and military.

2) C/E tradeoffs.

3) On-demand instructional value.

4) Impact of instructional culture.

5) Instructional Development requirement.

It was generally agreed at the workshop that Distance Learning has been used for generations. It follows from these topical concerns that the opportunity and the challenge now is for nations to integrate computers and other advanced technologies (e.g., networks, animation, DVI, etc). A modern comprehensive Distance/Distributed Learning program would take advantage of these. A model or approach for representing the various components which must be integrated when designing Learning Systems, was developed at the workshop and provided the framework for my presentation.

Effectiveness and Cost of Distributed Instruction Technology

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Interactive courseware (ICW) and video teletraining (VTT) are being used to distribute instruction to physically dispersed learners. This paper briefly reviews what we have learned about their effectiveness and cost.

Effectiveness. Meta-analysis has been used to combine the quantitative results from assessments of ICW. Meta-analysis uses a measure called effect size, which is defined as the difference between the means of two treatment groups divided by either a control group or a pooled standard deviation. Roughly, an effect size of 0.50 suggests an improvement in student performance from the 50th to the 69th percentile.

Two ICW media are considered: computer-based instruction (CBI) and interactive videodisc instruction (IVI). Effect sizes for CBI used in elementary schools, secondary schools, colleges, and adult education have been found to be 0.47, 0.40, 0.26, and 0.42 respectively. Effect sizes for IVI used in colleges, industrial training, and military training have been found to be 0.69, 0.51, and 0.39, respectively. Six studies of IVI compared different levels of interactivity. Effect sizes were higher for the more interactive approach in all six studies.

There are not sufficient data for meta-analyses of VTT. Four assessments of VTT have been performed by the US military using end-of-course achievement as the criterion. An Army study found that 1V/2A and 2V/2A were equally effective and both more effective than residential delivery in providing a specified course. An Army study of its SEP (1V/2A) system found that satellite, residential, and local (using a traveling instruction team) delivery of instruction were equally effective across 11 courses. A Navy study of a 2V/2A system found residential and remote delivery of 13 convenings of a single course to be equally effective. An Army study of a 1V/2A system found remote to be more effective than residential delivery on 3 of 4 outcome measures.

Costs. Since 1979 at least three reviews have concluded that the cost of CBI is less than the cost of conventional instruction due to an average 30% savings in student time. Cost ratios for 13 IVI programs were found. All 13 were lower than 1.00 indicating lower costs for IVI. Five ratios were for initial investment costs and averaged 0.43; eight were for operating and support costs and averaged 0.16. A times savings of about 30% was also found for IVI.

The Army SEP study of 1V/2A found costs per student week for satellite, residential, and local delivery to be $874, $1182, and $376, respectively. The Navy study of 2V/2A reported savings of $68,721 for the 13 remote convenings of their course. An Army study of costs alone to deliver a course found analog satellite, digital satellite, local, and residential delivery to be $611, $419, $877, and $2012 per student, respectively.

The issue should not be just <u>if</u> ICW and/or VTT should be used but <u>how</u> they can best be used to obtain the instructional results needed. The results thus far are promising, but conclusive evidence awaits more studies in which both cost and effectiveness data are collected under the same evaluation design.

An Air Force Perspective on Distance Learning

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The Air Force Air Education and Training Command (AETC) conducted an extensive baseline study of distance learning technologies in academia, industry, and government in 1991. Basic findings indicated that many organizations were using various forms of distance learning ranging from satellite delivery of course materials to distribute stand-alone computer-based lesson materials. The basic motivation for using distance delivery technologies was to save travel costs associated with training. Little innovation existed in the selection and sequencing of distance learning training materials.

Armstrong Laboratory has hosted two distance learning symposia to maintain currency with state-of-the-art practice in distance learning. The most recent of these symposia was held in Denver in October 1993. The trend reported in the earlier 1992 symposium was to use satellite technologies to replicate the classroom at a distance with as much fidelity and as little expense as possible. The 1993 meeting, however, revealed strong interest in using distributed networks as an integral part of instructional delivery. Satellite delivery is based on a mass communications model and it certainly has appropriate uses, both in terms of cost effectiveness as well as in distance delivery, however, is based on an interpersonal communications model. The difference in communications models implies a likely difference in areas of optimal utility. Where one kind of technology might be weak the other may be strong.

The differences in mass and interpersonal communications models suggests that consideration be given to rigorous testing of a wide variety of distance learning strategies, ranging from collaborative networked environments to very high fidelity two-way audio/video transmissions, across a variety of student profiles and subject matter. The point of conducting this research is to establish a guide for effective integration of technologies into instructional development. Current Air Force R&D in this area is explicitly directed to this last concern.

Implementation Issues in Distance Education

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Distance education is hardly a new development; correspondence study began in the 19th century. Instructional television, which is now experiencing a resurgence in the form of satellite delivery, is an innovation of the 1960s and computer-mediated communication (aka networking) appeared in the 1970s. A number of large-scale distance learning institutions and programs have been in operation for a decade or two. So we have had many years to learn how to do distance education successfully.

What have we learned? First, we have learned that distance education is a complex undertaking and requires a major overhaul of the existing infrastructure designed for classroom teaching. Teachers need to teach differently (and hence need to be trained with new skills). A high degree of planning and preparation of curriculum and materials is needed in any form of distance education, unlike the "seat of the pants" mode of most classroom teaching. Distance learning programs need different administrative procedures and structures than those currently used in traditional schools. For example, learner support (especially tutoring and counseling) is a critical component of successful distance education -- but not one that receives much attention in conventional classroom instruction. Finally, distance education tends to be capital intensive, requiring considerable initial funds for program development and acquisition of delivery systems. This usually means cost-benefit studies and business plans -- analytical methods that few educational administrators are comfortable with.

The successful implementation of distance education requires a systems approach -- careful attention to all instructional and administrative components and their interactions. Even small-scale efforts at distance education require major changes in the way things are done. Being aware of all these changes, and figuring out how to make them, is the biggest challenge of distance education.